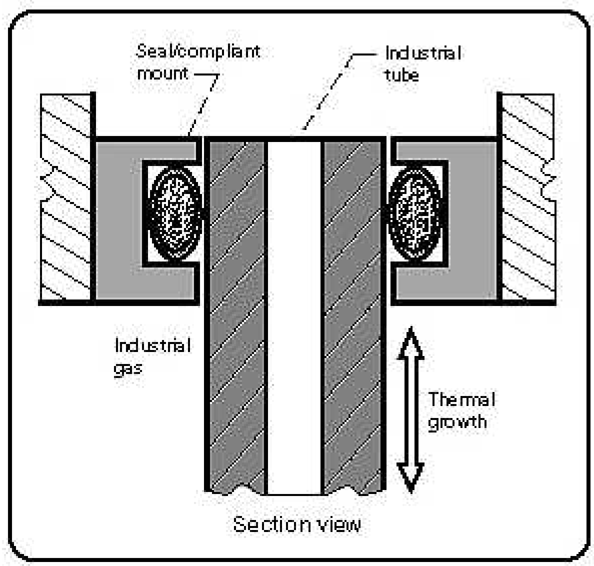
Feasibility of Rope Seal Technology Demonstrated for an Industrial Application

As the operating temperatures of industrial systems and advanced gas turbines continue to rise, designers are facing increasingly more difficult challenges in implementing high-temperature structural materials and seals to meet system performance goals. To maximize efficiency, they are reducing seal purge flows to their practical minimum and are requiring low-leakage seals to be made of temperature-resistant superalloy and ceramic materials. Seals are being designed to both seal and serve as compliant mounts, allowing for relative thermal growths between high-temperature, but brittle, primary structures and the surrounding support structures (see figure).



Technology transfer case study. Problem: An industrial application required a high-temperature, flexible seal/compliant mount to seal apparatus and prevent excessive structural loads. Solution: NASA demonstrated the feasibility of a compliant seal/mount arrangement that met the industrial customer's flow and durability goals--it operates hot (1500+ °F), exhibits low leakage, allows 0.3-in. relative thermal growth without binding or abrasion, and is chemically inert.

Under a cooperative agreement with a major supplier of industrial gas products, the NASA Lewis Research Center has demonstrated the feasibility of all-ceramic and hybrid rope seals for a tube seal application. In this application, a seal is designed to serve as a seal and a compliant mount, allowing relative thermal growth between a high-temperature, low-expansion rate primary tube structure and a higher expansion rate structural support, thereby preventing excessive thermal strains and stresses. The all-ceramic seal consists of a tightly packed ceramic core (alumina-silica) overbraided with a ceramic sheath for low-leakage, low-scrubbing environments. The hybrid seal, which consists of a tightly packed

ceramic (alumina-silica) core overbraided with a superalloy (cobalt base) wire sheath, was tested as an abrasion-resistant alternative.

High-temperature flow and durability were measured for both the all-ceramic and hybrid seals. Flow tests were performed in a unique NASA Lewis high-temperature test rig capable of 1500 °F. Compression tests in displacement control mode were used in conjunction with pressure-sensitive film to determine seal contact pressures and establish required groove-depths to set seal preload in the flow tests. (Braided seals exhibit hysteresis (i.e., nonrecoverable displacement) during loading and have a memory of previous loading conditions.) The seal flows met the acceptable flow goal for the design preloads. Furthermore, sheath damage was minimal over the thermal cycles.

On the basis of these observations, which were made during Phase I, the braided seal was deemed feasible for the industrial tube seal application. As a result, NASA has entered into a Phase II Space Act Agreement with our industrial customer to transfer the seal technology to the actual industrial application. Lewis personnel will be helping the industrial customer insert these seals into their proprietary system. The industrial partner has expressed interest in licensing the rope seal technology from NASA after the seals have been qualified in the prototype system.

Bibliography

Steinetz, B.M., et al.: High Temperature Braided Rope Seals for Static Sealing Applications. AIAA Paper 96-2910 (Also NASA TM-107233 Revised), 1996.

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